Extravehicular Activity Technology Development—Portable Life Support System Integrated Testing

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A spacesuit provides distinct protection for a single crew member who is working and operating in challenging extravehicular activity (EVA) environments. An EVA system is a key component of any plans for the future human exploration of space. The EVA system typically consists of a suit; a Portable Life Support System (PLSS); a Power, Avionics, and Software System; and suit interface hardware. The PLSS, which houses the Power, Avionics, and Software System components, consists of the oxygen subsystem, ventilation subsystem, and thermal control subsystem. As a unified system, the PLSS provides all of the functionality for breathing, pressurization, and cooling required to keep the crew member alive, comfortable, and protected during an EVA.

Since 2008, EVA technology development has focused on maturing key component technologies for each of the subsystems within the PLSS. The advancement of these technologies will improve hardware life, robustness, on-back regeneration, and mission flexibility. These advancements incorporate multiple technologies over current state-of-the-art capability and will keep the crew member alive more efficiently during an EVA. Johnson Space Center (JSC) has developed both an advanced PLSS concept design and a detailed schematic based on system analysis of each of the developmental hardware components. This promising PLSS design represents a significant state-of-the-art improvement over current extravehicular mobility unit technology. The overall PLSS schematic has been matured, and individual hardware component testing for each of the developmental subsystems has been achieved over the last several years and continues with promising results. The developmental

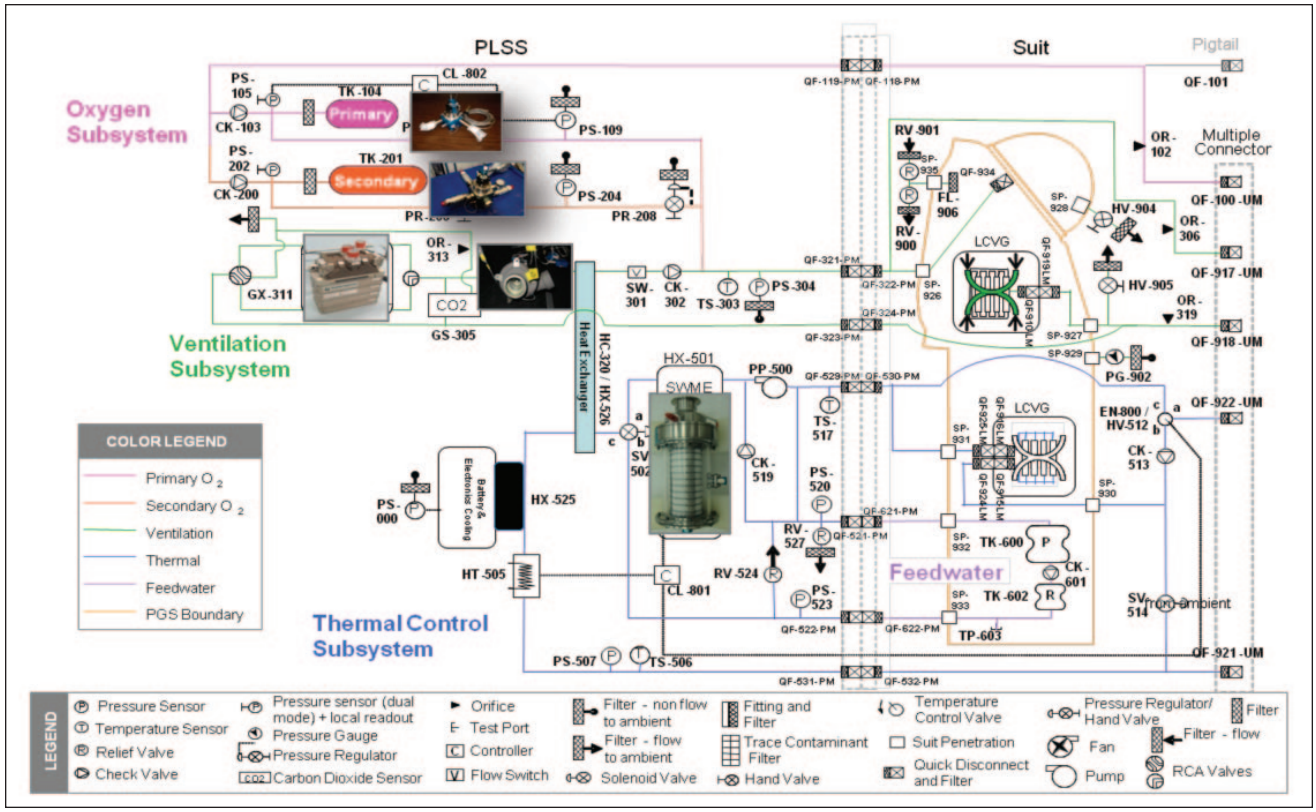

Fig. 1. *System-level baseline Portable Life Support System schematic showing the components.*

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continued

components include a primary oxygen regulator, a secondary oxygen regulator, a spacesuit water membrane evaporator, a rapid cycle amine, a fan, and a pump. Now that many of these technologies have been successfully demonstrated at a component level, integrated system evaluations of the entire assembled and integrated system are critical to advance the PLSS design further (figure 1). Therefore, integrated test planning has been under way, and testing will commence in fiscal year 2011 (FY11) by the EVA Technology Development Team, which is within the Crew and Thermal Systems Division of JSC.

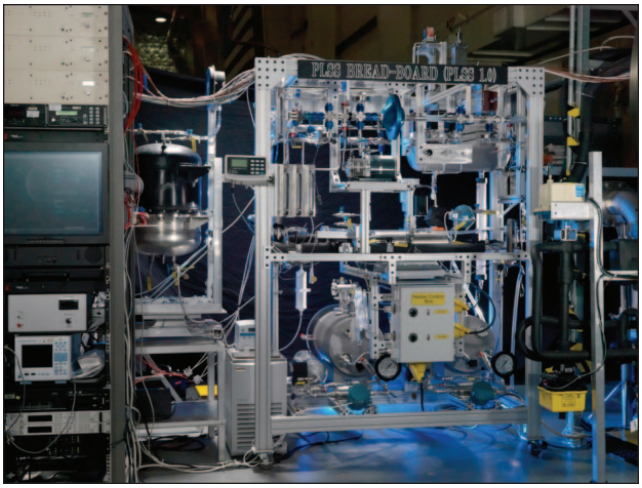

Fig. 2. *Portable Life Support System breadboard 1.0 test stand.*

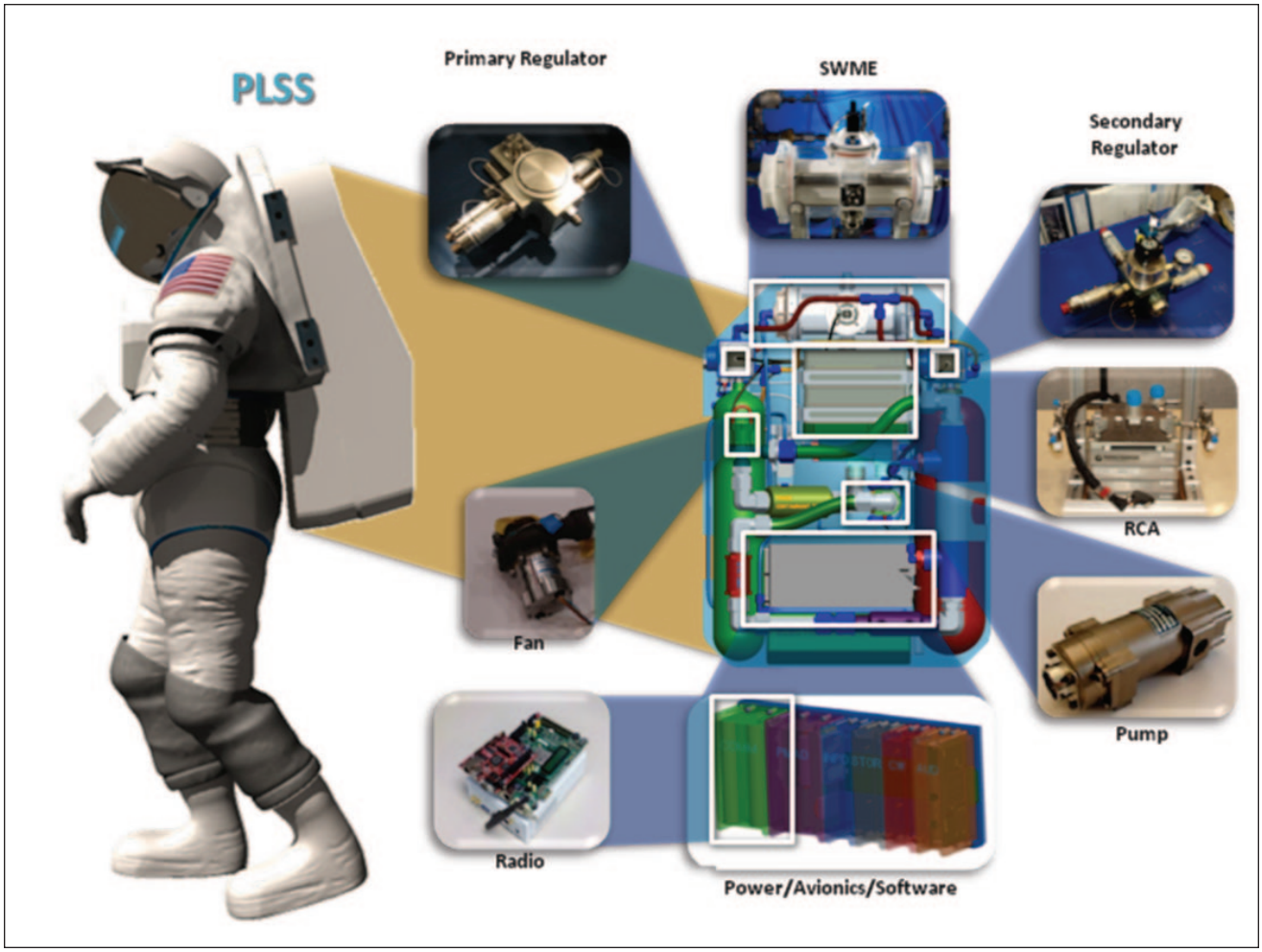

Fig. 3. *Advanced Portable Life Support System 2.0 design concept with component technologies for each subsystem.*

Portable Life Support System Integrated Breadboard Test

Integrated testing of EVA development hardware marks the first new major system-level evaluations since the development of the Space Shuttle Extravehicular Mobility Unit Program more than 3 decades ago. The first system demonstration—PLSS 1.0—will focus on integration of the next-generation PLSS. The test configuration is based on the PLSS schematic developed for integrating each subsystem component completed prior to FY11. The breadboard (figure 2) has been configured and approved for testing in FY11. Since this is the first attempt at system demonstrations, the hardware will be arranged in breadboard fashion and test objectives will focus on demonstrating primary system functions. The primary objective of the PLSS 1.0 series is to demonstrate system performance through a series of human metabolic profiles and thermal loads, and to obtain engineering data characterizing the performance of a PLSS-integrated system in a benchtop environment using simulated human and vehicle interfaces. The tests will demonstrate the operation of the benchtop PLSS in nominal intra-vehicular activity (i.e., pre- and post-EVA), EVA, and recharge configurations as well as under certain failure conditions. The tests will experimentally characterize the actions of the integrated system to define the system more precisely for modeling purposes, identify unexpected interactions and modes of operation, and build confidence in the system design. All breadboard testing will be crewless and will use nitrogen as the primary gas constituent, rather than air or pure oxygen. This is because pure nitrogen is safer than both pure oxygen and air, as pure nitrogen is nonflammable. At the same time, pure nitrogen will work well with all components of the ventilation loop and will give results comparable to a 100% oxygen system.

The PLSS 1.0 series only represents the initial system evaluations needed to develop an advanced EVA system. Follow-on system demonstrations will increase in complexity, evolving to include flight-like packaging and human test subjects. Future development activities will involve performing system trade studies and analyses; maturing system design to flight demonstration; packaging a PLSS 2.0 test article (figure 3) with the spacesuit water membrane evaporator, rapid cycle amine, primary regulator, fan, and secondary regulator; performing PLSS 2.0 testing; and ultimately carrying out human-rated testing (PLSS 3.0).